

REMARKS

An etching solution of the present invention comprises hydrofluoric acid, nitric acid, and hexafluorosilicic acid, the concentration of the hexafluorosilicic acid being not less than 10% by weight.

This invention provides an etching solution that is capable of producing a semiconductor wafer, especially a silicon wafer, which has an improved flatness, and is free from the formation of waviness over its whole body. The etching solution readily etches at an optimum rate, maintains an etching rate that is stable, and is readily reusable.

Since the fluorosilicic acid acts as an inhibitor to the etching reaction, a nitric acid/hydrofluoric acid-based etching solution containing hexafluorosilicic acid at not less than a predetermined concentration, can readily control the etching speed and exhibit excellent performance without allowing the etching reaction to go out of control.

Upon etching the silicon wafer, hydrofluoric acid and nitric acid are consumed to produce hexafluorosilicic acid, water and nitrogen monoxide as reaction products. The waste etching solution can then be reused by removing the hexafluorosilicic acid produced by the etching, and replenishing the hydrofluoric acid and nitric acid consumed by the reaction.

When the concentration of the hexafluorosilicic acid is too low, for example, less than about 10 % by weight, the etching speed is so high that the etching solution tends to become unusable. Additionally, in an etching solution where the

concentration of the hexafluorosilicic acid is too low, again, less than about 10 % by weight, the amount of water contained in the etching solution becomes large, and a wafer etched by such a solution will tend to be of poor quality.

Claims 1-7 have been rejected as unpatentable over Lee (US 6,284,712) in view of Uchida (US 5,307,296).

US 6,284,712 to Lee et al., discloses a cleaning composition for cleaning substrates having a silicon oxide layer, that releases fluoride ion into an aqueous solution during cleaning; etching processes for reacting with silicon; and a persulfate which decomposes and releases hydrogen peroxide in the aqueous solution for increasing the oxidation effect of the fluoride.

As noted in Lee, an exothermic reaction occurs in conventional mixed acid solutions during etching, and the solution temperature increases by 20°C in about 1 - 2 minutes, while the wafer is etched by approximately 30 micrometers. Thus, with conventional etchants that use HF, the etching rate is difficult to control, and etching imparts considerable etching damage onto the silicon wafers.

In Lee, control of the etching reaction is accomplished with the use of fluorides instead of HF. Col. 6, lines 63-66. The etching rate is controlled by adjusting the concentration of the fluorides. Col. 6, lines 66-67. Thus, in Lee, there is generally no need for the use of an inhibitor to control the etching rate.

Furthermore, in Lee, it is pointed out that H_2SiF_6 is not produced at all, as in the present invention. Col. 10, lines 7-8, equation 8. Lee points out that the

comparatively safe $(\text{NH}_4)_2\text{SiF}_6$ is produced, which is a salt, unlike H_2SiF_6 which is an acid. Col 10, lines 23-26.

Therefore Lee's invention is quite different from the present case. In the present invention control of the etching reaction is accomplished with the use of H_2SiF_6 , being not less than 10% by weight.

US Patent No. 5,307,296 to Uchida et al., relates to a method of accurately predicting the topography of a semiconductor workpiece after a plurality of processes have been carried out on the workpiece. This is in order to determine appropriate process conditions for manufacturing a semiconductor workpiece having a desired topography. Uchida is cited as authority for the proposition that etchant concentration is a result effective variable, and that discovering its optimum value would involve only routine skill in the art.

As discussed, the etchant solution described in Lee is completely different from that of the present invention. Since Lee does not disclose the use of H_2SiF_6 as an inhibitor for an etching composition at all, optimizing its concentration could not be made obvious through Uchida.

Through the combination of Lee and Uchida, one of ordinary skill in the art would not be apprised of an etching solution that readily selects an optimum etching speed; maintains a stable etching rate; is readily reused in extensive application fields; is capable of providing a semiconductor wafer, especially a silicon wafer, which shows an improved flatness and gloss; and is free from the formation of waviness over its whole body. To accomplish these objectives, one having

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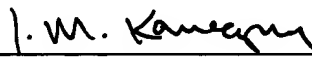
ordinary skill in the art would not strike upon the use of an etchant composition with a hexafluorosilicic acid concentration of not less than 10% based on the weight of the etching solution.

It is not believed any additional fees are required, however, if an additional fee is required, or if an overpayment is made, please charge/credit deposit account 04-1105.

It is respectfully submitted that the present application is in condition for allowance. An early consideration and notice of allowance are earnestly solicited.

Respectfully submitted,

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